NorduGrid, the middleware and related projects

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2001–2002: a research project of the NORDUNet2 program aimed to enable Grid in the Nordic countries

Since end–2002 is a research collaboration between Nordic academic institutes
- Open to anybody, non-binding

Since end–2003 focuses on middleware
- Develops own Grid middleware: the Advanced Resource Connector (ARC)
- Provides middleware to research groups and national Grid projects

ARC is now installed on ~50 sites (~5000 CPUs) in 14 countries all over the World
The NorduGrid Collaboration

From ... ... To

- EDG
- Tesbed
- HEP
- 4 Nordic
- 20 cpu’s
- 2001

> ARC
> 50 sites
> Bio, Chem,...
> 13 countries
> 5000 cpu’s
> 2003

... from a research project to a research collaboration
... from a Grid testbed to a major middleware provider

NOT an infrastructure, does not operate or control resources
How did ARC appear

- Back in 2001...High Energy Physics Institutes from Scandinavia wanted to share their computing resources and jointly contribute to CERN/LHC computing
  - They needed a Grid!
  - The Grid hype just begun
  - Globus was regarded as the “de facto standard” middleware
- NO production ready middleware was available or seen on the horizon as of November 2001:
  - Very alpha Globus GT–2.0 (GRAM–1.5, MDS–2.0); nevertheless Globus & IBM already started to work on OGSA/I, i.e. GT v.3 (which was announced in February 2002)
  - EDG middleware was in an extremely embryonic phase
- Since May 2002 ARC has been used in production Data Challenges
1. The system must be:
   a) Light-weight
   b) Portable & modular
   c) Non-intrusive on the resource side:
      • Resource owners retain full control
      • No requirements w.r.t. OS, resource configuration, etc.
      • Clusters need not be dedicated
      • Runs independently of other existing Grid installation
   d) Special attention to functionality & performance

“Traditionally, Scandinavian design has been associated with simple, uncomplicated designs, functionality and a democratic approach”

www.scandesign.org
Design philosophy (2/2)

e) Flexible & powerful on the client part

- must be easily installable by a novice user
- trivial tasks must be trivial to perform
- no dependency on central services
- No central client(s), create a real distributed system

2. Strategy: start with something simple that works for users and add functionality gradually

Source of design illustrations:
“Scandinavian Design beyond the Myth”
www.scandesign.org
ARC components

Goal: no single point of failure
Architecture key points

- Each resource has a front-end
  - Authenticates users, interprets tasks, interacts with LRMS, publishes information, moves data
  - Resources are Grid–enabled by the ARC layer deployed on the front–end, no middleware components behind the front–end!

- Each user can have an independent lightweight brokering client (or many)
  - Resource discovery, matchmaking, job submission and manipulation, monitoring

- Grid topology is achieved by an hierarchical, multi–rooted set of indexing services

- Monitoring relies entirely on the information system

- Ad–hoc data management, for the beginning
Computing resources: Grid-enabled via ARC layer on head node (front-end):
- Custom GridFTP server for all the communications
- Grid Manager handles job management upon client request, interfaces to LRMS
- Performs most data movement (stage in and out), cache management, manages user work area
- Publishes resource and job information via LDAP
Components: Clients

- **Client**: a lightweight *User Interface* with the built-in Resource Broker
  - A set of command line utilities
  - Minimal and simple
  - Under the hood: resource discovery, matchmaking, optimization, job submission
  - Complete support for single job management
  - Basic functionality for multiple job management
  - Support for single file manipulations
  - Built upon ARCLIB

- Portals and GUI clients are being developed
Components: Infosystem

- **Information System**: based on Globus-patched OpenLDAP: it uses GRIS and GIIS back-ends
  - Keeps strict registration hierarchy
  - Multi-rooted
  - Effectively provides a pseudo-mesh architecture, similar to file sharing networks
  - Information is only kept on the resource; never older than 30 seconds
  - Own schema and providers
Components: Storages

- **Storage**: any kind of storage system with a disk front-end
  - **Conventional Storage**:
    - Own GridFTP server implementation with pluggable back-ends
    - Ordinary file system access
    - Grid Access Control Lists (GACL) based access
  - **“Smart” Storage Element**: WS based data service with direct support for Indexing Services (Globus’ RC, RLS)
  - no tape storage systems in use so far
Functionality overview

- Provides reliable implementation of fundamental Grid services:
  - The usual grid security: single sign on, Grid ACLs (GACL), VOs (VOMS)
  - Job submission: direct or via matchmaking and brokering
  - Information services: resource aggregation, representation, discovery and monitoring
  - Implements core data management functionality
    - Automated seamless input/output data movement
    - Data Indexing (RLS, Fireman), client-side data movement
  - Job monitoring & management
  - Logging service

- Builds upon standard open source solutions and protocols
  - Globus Toolkit® pre–WS API and libraries (no services!)
  - OpenLDAP, OpenSSL, SASL, SOAP, GridFTP, GSI
What is ARC today

- General purpose Open Source European Grid middleware
  - Being developed & maintained by the NorduGrid Collaboration
  - Deployment support, extensive documentation
- Lightweight architecture for a dynamic heterogeneous system
- User- & performance-driven development
  - Production quality software since May 2002
  - First middleware ever to contribute to HEP data challenge
- Middleware of choice by many national academic projects due to its technical merits
  - SWISS Grid(s), Finnish M-Grid, NDGF, etc...
  - Majority of ARC users now are NOT from the HEP community
- Involvement in Interoperability initiatives
  - LCG <-> ARC gateway
- Strong commitment to provide implementations of standards:
  - JSDL, GGF Usage Record support with the coming release
ARC development status

- Production sites run stable releases 0.4.x
  - Released in April 2004, took 2 years to develop
  - Globus 2, pre-WS technology, most basic functionality
- Development branch 0.5.x is already used as a release candidate
  - In ATLAS’ Dulcinea executor and other clients
  - Deployed at several sites, offers production-level functionality not available in 0.4.x
  - Perfectly backward-compatible: NorduGrid is a mixture of 0.4.x and 0.5.x sites and clients
- Release 0.6 should be out *real soon*
  - Re-write of the client part, configuration etc needed more bug fixing than anticipated
  - … and many authors are not even employed by the NorduGrid members, had to work extra-time
  - … and some non-anticipated requirements (e.g. VOMS, SRM) appeared meanwhile
  - Currently working on documentation and packaging; 0.5.48 and 0.5.49 are good release candidates
  - Will be easy to upgrade; no simultaneous upgrade of the sites necessary
What is new in ARC 0.6

- New external software, new packaging and distribution
  - Globus 4 based (pre-WS components, e.g. GSI, gridftp libraries, LDAP backends)
  - Latest VOMS, GSOAP
  - Natively works on 64bit architectures
  - Streamlined configuration
  - Software repositories (e.g. apt, yum)
- Major re-write of the client code base
  - Modularity
  - Multithreaded implementation
  - Extensibility
- Client libraries, modules available for C++ (native), Python, Perl etc – via SWIG, and Java
  - Easy to use API for clients that need to interface to ARC, e.g. GUIs, portals, CLIs
- Many new attributes in the information system
  - Better monitoring and decision-making
  - Improved job description
- Even more extensions on the server side:
  - Authorization, security: VOMS, MyProxy support, GACL for jobs
  - JSDL support
  - SRM support (also in the data movement client)
  - LSF support; PBS, SGE and Condor interfaces significantly improved
More new features

- “Smart Storage Element” (SSE) is a part of the release
  - Files instantiated at an SSE are registered in e.g. RLS automatically
  - Has a basic SRM interface
- Non-root ownership of services
- Performance improvements of the core services
- Logging infrastructure: new Usage Record format, better performance
- Improved monitoring
- Localization of clients (user interface, monitor)
- Improved usability: notifications, logs, command line options
What is not (yet) in ARC 0.6

- Bulk data manipulation tool
  - ARC file transfer service is needed
  - Data management user interface

- Own data indexing tool
  - External tools are interfaced (RC, RLS, Fireman, maybe LFC)
  - None is satisfactory (no data collection support, no fine-grained access control, no integration with data manipulation tools)

- Own full-scale SRM solution
  - SRM proxy is under development

- VO-aware monitoring and accounting; VO-specific attributes in information system
  - User-friendly interface to logging/accounting systems
  - Lightweight logging/accounting
  - Security layer over information and monitoring services

- User-friendly client
  - A Java-based GUI prototype (the “Arconaut”) exists, not mature enough to be in 0.6
  - Brokering needs to be improved
  - “Off-line” job management functionality (“babysitting”) is needed
The KnowARC project

- **EU FP6 Specific Targeted Research Project**
  - "Grid–enabled Know–how Sharing Technology Based on ARC Services and Open Standards"
  - Start: June 1st, 2006 (signature still on its way)
  - Partners: NorduGrid members and research teams in medicine, bioinformatics, physics, engineering, automotive industry apps, IT (10 partners from 7 countries)

- **Objectives:**
  - to create a novel, powerful Next Generation Grid middleware based on ARC, widely respected for its simplicity, non-invasiveness and cost-efficiency;
  - to promote Grid standardization and interoperability;
  - to contribute to Grid technologies take–up, bridging the gaps between business and academia in Grid development

- **Will develop the middleware that will be the next step after ARC 0.6, addressing current limitations and shortcomings**
KnowARC development plan

- **Core Services**
  - Next generation Grid middleware architecture survey and design
  - Web Service interfaces over ARC services
  - Back-ends
  - Sandboxing & virtualization
  - Security framework (delegation)

- **Higher level services**
  - Self-healing flexible storage and user-friendly storage interface
  - Self healing grid jobs: job migration & job manager
  - P2P-like information backbone, novel brokering approaches
  - Scalable accounting service
  - Dynamic application framework management
  - ARC-enabled Taverna and flowGuide (workflow engines)

- **Standards & Interoperability**
  - OGSA
  - gLite gateway

- **Applications**
  - Automotive industry
  - Medical image processing
  - Statistical genomics
  - Engineering portal (construction industry)

- **Quality assurance, software distribution**
  - Build system, testing, support
  - Profiling, performance analysis, usability studies
  - Pilot Grid system
  - ARC in major Linux distributions
  - New platforms: Windows, Solaris, Mac OS-X
ARC and gLite: wish to interoperate
Nordic Data Grid Facility

- **NDGF == “Nordic Data Grid Facility”**
  - Idea conceived in 2002 simultaneously with LCG
  - Goal: create a Nordic Grid infrastructure, primarily for LHC Grid computing (Tier1)
  - 2003–2006: pilot project funded by the 4 Nordic countries (Denmark, Finland, Norway, Sweden)
  - NorduGrid/ARC middleware chosen as the basis
- **June 1st 2006: NDGF is launched**
  - Nordic production Grid, leveraging national grid resources
  - Common framework for Nordic production Grid
  - Co-ordinates & hosts major Grid projects (e.g. the Nordic LHC Tier-1)
  - Develops Grid middleware (*ARC contributor*)
  - Single Point of Entry for collaboration, middleware development/deployment, e-Science projects
  - Represents the Nordic Grid community internationally
- **NDGF 2006–2010**
  - Funded (2 MEUR/year) by National Research Councils of the Nordic countries (NOS–N)
- **NDGF coordinates activities** – does not own resources or middleware

[Diagram showing the Nordic Data Grid Facility with countries and their abbreviations: DK (Denmark), SF (Sweden), N (Norway), and S (Finland).]
Summary

- ARC middleware is approaching the milestone of the second stable release (v0.6)
- Being based on old technologies, has severe limitations and shortcomings
- ARC developers have a clear roadmap for further development, and start enjoying substantial support
  - EU FP6 KnowARC project, with many partners from different research areas
    - Ambitious plans to extend and re-design ARC
  - Nordic Data Grid Facility
    - Came into existence on June 1st as well
    - Rely upon ARC middleware, will employ a number of middleware developers
- Interoperability and standardization needs are among the major driving forces behind further ARC development